Electronic Waste Recycling in the Bay Area, California: What Do People Really Know?

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Abstract In 2006, the U.S. generated 2.9 million tons of electronic waste, of which only 11.4% was recycled while the rest was trashed into landfills. Approximately 50-80% of this waste was dumped overseas in third world countries to exploit cheap labor and additional sources of dumping. This study examines the relationship between educational levels and the knowledge of environmental impacts, and assesses recyclers' perception of electronic waste recycling facilities. Questionnaires and interviews were conducted to one out of every three subjects exiting three local Bay Area recycling facilities. A weak positive relationship between educational levels and the knowledge of environmental impacts was shown to be statistically significant ($R^2 = 0.25$, $p = 0.04$). In addition, recyclers were shown to generally care for how a recycling facility operates despite initially being unaware of the facility's disposal policies. The study concludes that education and recycling awareness are essential to determining the motivation of a recycler.

Introduction

Increasing rates of electronics ownership has resulted in an ever increasing production of electronic waste (e-waste) that is being mostly thrown into landfills or incinerated, causing environmental hazards and risk to everyone in the nearby vicinity (Binns *et al*. 2006). E-waste is defined as broken, surplus, or discarded electronic devices. In 2007, 67 million computer units were shipped worldwide by manufacturers to be sold in the U.S., up 14.3% from the previous year (IDC 2007). In 2008, it is also predicted that this number will rise to 71.7 million in the U.S., and by 2012, 85 million computers and rising (ETBC 2008). Similar trends could be seen across all other types of electronics such as big screen TVs, which only get bigger and better every year. The Consumer Electronics Association predicted that in the U.S. during 2008, consumers would purchase over 500 million units of electronics (CEA 2007). The U.N. predicts that cellular phone users in the U.S. will reach a staggering 250 million by the year 2009, approximately 82% of the U.S. population (ETBC 2008). With technology improving at a drastic rate, a piece of electronic equipment bought at a store is said to become obsolete as soon as it is out the door, which contributes to these figures.

Consumerism and planned obsolescence, which is the producer-planned life expectancy of their product, have caused people to discard their electronics at a much faster pace than ever before (Tong & Wang 2007). The U.S. generated 2.9 million tons of e-waste in total in 2006 (IAER 2006). Only about 11.4% was recycled, the rest was thrown into regular trash containers and emptied into landfills (EPA 2007). The EPA estimates that approximately 234.6 million unused electronic products were stored in people's homes during 2007; products were unused due to malfunction or old age. These products accounted for 68% of the total stockpiles that consumers kept in their homes or storage (EPA 2007). The trend demonstrates that the growth in recycling is low in proportion to the enormous growth in product purchasing and waste disposal.

Ecologists and environmentalists are pushing to pass regulations to curb the production of waste in general, but especially electronic waste, as it is fastest growing category of municipal waste in America (ETBC 2008). From the period of 2005 to 2006, the total increase in volume of e-waste produced was 8.6% while the total increase in volume of total waste produced increased by only 1.2% (ETBC 2008). This is a problem not only domestically but also overseas as approximately 50-80% of the e-waste produced in the U.S. that do not enter landfills or incinerators are exported overseas to developing countries where they are dumped into

particularly poor rural communities (ETBC 2008). A 60 Minutes segment on November 9th, 2008 reported a Colorado-based recycling company that allegedly engaged in illegal dumping of e-waste in poor communities in Hong Kong (60 Minutes 2008). The report showed footage of dirty and destitute environments with children playing around in e-waste incinerating facilities, with dark air and ash coming off of the smoldering remains of burnt e-waste. The stream beds where water should have been flowing were caked in dark, wet ash, and the reporter was visibly coughing through the musky air as he described the acrid conditions of where he was standing. These companies know that very cheap labor can be found in such poor communities where people are willing to work for any job, no matter how low the pay or how dangerous the working environment can be. People were seen on footage, wearing only a light facemask while picking apart liquid metals from computer parts that are highly toxic to the human body. Further studies have shown that such e-waste recycling sites in Hong Kong are major sources of various toxic chemicals highly detrimental to the environment and human health, due to the combustion of e-waste in open air and dumping of processed materials (Wong *et al.* 2007).

It is difficult to trust such e-waste recycling companies with honest recycling practices. When customers leave their e-waste at a recycling facility, they expect the equipment to be properly taken apart and disposed. More likely than not, the company will not reveal their highly illegal practices because they can be punishable by law. It causes a breach of trust between the company and its customers to outsource the e-waste to developing countries. It is interesting to see if consumers consider a recycling facility's disposal practices when making the decision to recycle at that location. A study on e-waste recycling behavior has revealed that those who recycle generally do not realize how their recycling can affect the environment in the bigger context (Hunt 2006). These people were essentially choosing to recycle while largely unaware of their environmental impacts. Therefore it is questionable as to whether they were aware of the facility's recycling policies or how that knowledge could affect their future decisions to recycle. No research is done in this area of consumer perception of e-waste recycling facilities.

Much legislation has been passed in the last decade to address this growing e-waste issue. Among others, the state of California passed the Electronic Waste Recycling Act (EWRA) in 2003 to help fund e-waste recycling facilities and set ground rules for the proper disposal of the hazardous waste by charging consumers a state-wide fee based on the size of the screen display purchased (DTSC 2007). There are currently 17 U.S. states that impose this type of fee or service

for each unit sold, something more commonly referred to as an "Advanced Recovery Fee" (ETBC 2008). There is the "Producer Responsibility Obligation" regulation as well that requires manufacturers to reclaim their products should they become obsolete and the consumer wants to dispose of it properly (ETBC 2008). All retailers are required to turnover this fee to the state for every "screen" transaction where it is redistributed to recycling centers that offer free e-waste recycling solutions to consumers and businesses. The idea is that years down the line when that product becomes obsolete, these fees are meant to cover the cost of recycling it properly. Though these regulations are a step towards the right direction, it is difficult to prove their effectiveness in reducing e-waste. Recycling rates have stayed fairly constant in the past couple of years as the number of recycled units has increased, but not proportionally to the total number of units gathered in e-waste due to the ever-increasing supply of obsolete electronics that are thrown out (EPA 2007).

One of the big reasons for such an influx in e-waste found in landfills is that consumers may find it difficult to recycle for many different reasons (Kang & Schoenung 2005). Studies also reflect that pro-environmental behaviors (in this case, recycling e-waste) could be encouraged by making recycling easier (Pelletier & Bellier 1999). In the case for electronics, one would have to drive to a potentially far recycling facility when they may not have access to a car. Some e-waste recycling facilities are not an entirely free service as they may charge a modest fee to properly dispose the e-waste. It is difficult to expect these consumers to realize their impact on the environment if they can simply dump their electronics in the trash, but in whatever their reason to do so, it is still evident that circumstances make it more favorable to do the less environmentally friendly action. Yet, there are those who still have the mindset to recycle and it is quite interesting to know what compels them to go out of their way to dispose properly.

Before we tackle the important issue of the lack of interest in recycling, we need to examine the development of a consumer's mindset towards recycling. The determinants of consumer behavior are heavily shaped by motivation and opportunity (Olander and Thogersen 1995). Their desire to recycle could also be said to derive from their upbringing, as in what they were taught to do as they grew up or what they are used to doing in the past. To fully understand these attitudes, it is important to examine the circumstances in which certain people are more motivated to recycle than others. Students who are more versed in the concepts of sustainability and recycling as they have grown up were more likely to understand their impacts on the

environment due to recycling (Pike *et al.* 2003). These days, more efforts are made to provide opportunities for children at an early age to learn about sustainability and recycling, starting from kindergarten (Pike *et al.* 2003). Perhaps this may indicate that among other factors, certain demographic variables may be related to recycling.

The purpose of this study is to discover the trends and patterns of Bay Area recycling. What can we discover from a recycler's perception of e-waste recycling that can help us better understand the issue of growing e-waste? The research questions I will be answering are as follows: How does educational level affect one's knowledge of environmental impacts? And of the people who do recycle e-waste, what do they think is happening in e-waste recycling facilities? I will be conducting demographic questionnaires and open-ended surveys to gauge trends in responses.

I predict that there will be positive relationship between educational levels and the knowledge of environmental impacts. Those who have knowledge learned from higher education will more readily realize the impacts of recycling on the environment. Also, I believe that consumers do not generally care for the actual processes of how an e-waste recycling facility operates; just the fact that they have a legitimate looking "front" is sufficient enough. Even if they were to know the processes, they still would not care enough because they will have felt that they did their job of recycling rather than having it end up in landfills.

Methods

I conducted an observational study using two different types of data collecting tools: a questionnaire and an open-ended interview. The study was conducted outside three major e-waste recycling facilities in the Bay Area. The locations were selected around the Bay Area: GreenCitizen Computer Recycling Center of San Francisco, CA and Los Altos, CA, and Alameda County Computer Recycling Center of Berkeley, CA. The facilities were chosen due to popularity among consumers in the Bay Area, which provided access to more subjects. I gained permission in writing from each of the facility managers beforehand. I conducted the data collections over a period of three weeks from March 28th to April 12th, and always collected on Saturdays and Sundays due to scheduling availability. The location alternated among the three test facilities every week during normal business hours so I visited each site twice in a row for that weekend. I collected a total of 30 responses, 10 from each site. It was a number that was

possible to achieve statistically significant results deriving causal relationships between two variables (Montello & Sutton 2006).

Subjects were selected from one out of every third person exiting the facility, as to promote ordered sampling. I approached the subjects and screened them first to see if they had recycled e-waste that day. If they said no, then I thanked them for their time. If they said yes, then I asked them to participate in the study. If they said yes, then I read them the informed consent script (Appendix A). If they agreed, then I handed them a questionnaire (Appendix B) to fill out. The demographic questionnaire asked for each subject's sex, ethnicity, age, highest level of education completed, total annual income, type of electronics recycled that day, and how knowledgeable they were about environmental impacts. This information was used to conclude which factors in the subject's life influences their decision to recycle faithfully when they could have just as easily thrown it out without anyone knowing. The purpose of the questionnaire was to tally the results of the demographics and to observe trends in characteristics of those who recycle. Subjects were not allowed to put their names on the form. Upon completion, I folded and inserted the questionnaires into a sealed box to ensure privacy of every identity.

I then conducted the interview (Appendix C) as questions were read directly off of the interview paper and as the subjects responded to each one, I took notes as well as recorded on my voice recorder. The purpose of the interview format was to gain an in-depth understanding of the experiences of each individual as well as accounting for the various types of answers received to each question (Wolcott 1994). The questions asked about the subject's motives behind recycling and gauged each subject's reactions to a hypothetical situation. The situation was that the e-waste recycling facility was found guilty of dumping e-waste in third-world countries. The interview was to gather subject's opinions on recycling and whether or not they cared enough about e-waste to know about the real processes of each facility. After the interview, I thanked each subject for their participation in the study and gave an information sheet with my contact information should questions arise.

I conducted both quantitative and qualitative analysis for this study. The demographic questionnaire information was analyzed using linear regression analysis between subject's educational level and self-rating of the knowledge of environmental impacts. This information was able to help determine the relationship between the two demographic variables and draw trends regarding the attributes of an e-waste recycler. The interview answers were gathered and

analyzed for common themes and responses for each question (Wolcott 1994). By doing this, I was able to find out the subjects' motives behind recycling and their reaction to the hypothetical situation.

Results

1st Research Question: How does educational level affect one's knowledge of environmental impacts? My research question pertained to two variables only, educational level and self-rating of the knowledge of environmental impacts. Educational level was ranked from 1 to 5: 1 = Less than 9th grade, 2 = High School, 3 = Some College, no degree, 4 = Technical or Associate Degree, 5 = Bachelor's Degree or higher. Knowledge of environmental impacts was rated from 1 to 10: 1 = no knowledge at all, 10 = very knowledgeable.

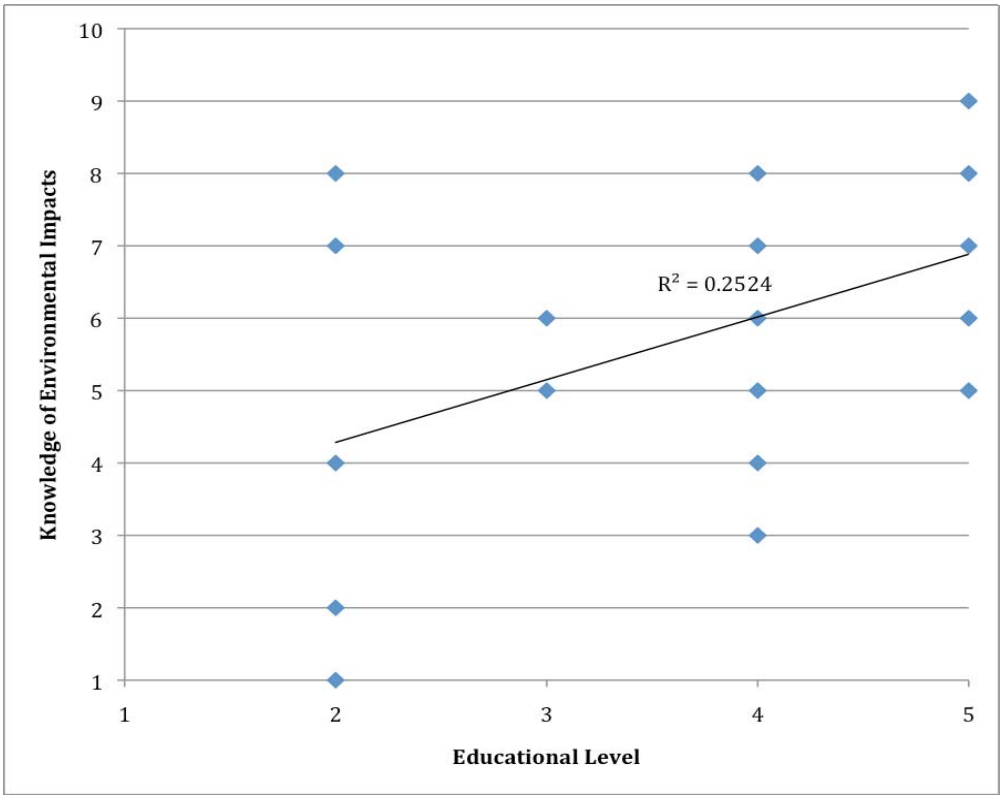

Figure 1: Linear regression between educational level (independent variable) and knowledge of environmental impacts (dependent variable) showed significant weak positive relationship ($R^2 = 0.25$ and $p = 0.044$).

2nd Research Question: Of the people who do recycle e-waste, what do they think is happening in e-waste recycling facilities? Responses to interview questions:

1. *Why did you decide to recycle today?* Many participants (46.7%) responded that it was something they felt was the right thing to do. 40.0% felt strongly about their decision to recycle because they were educated at school and taught to recycle in their households as they grew up. 30.0% stated that they realized how recycling impacts the environment if they did not recycle so it goes against their conscience if they did not. 16.7% said that they were forced to come one way or another, whether it was a spouse or parent who made them do it or because they just did not have enough space at home to store it. When asked what they would have done if no one instructed them to do anything about recycling, one of them replied, "Well, obviously I don't think I would be here talking to you right now," whereas the four other subjects stated they would still recycle the product, yet they all seemed hesitant in their answer as if they did not want to tell the truth.

2. *What do you think happens to the electronics that are recycled here?* An overwhelming majority (93.3%) stated that they do not know the disposal policies of the facilities where they bring their electronics. Most of the subjects (80.0%) believed that the electronics were properly disposed. Of these people, 33.3% believed that the electronics would be disposed on site, whereas 46.7% believed that the electronics would be disposed in a separate, but proper company affiliated location. Most surprisingly, the other 20% thought that they were probably shipped overseas. When asked how much they knew about the claim, they knew about the issue and in fact, all of them had seen the 60 Minutes segment about e-waste dumping overseas. Of these people, 6.7% actually knew the policies of the e-waste recycling facility where they were recycling their electronics after having contacted the company, whereas 13.3% did not know the company policies just like the rest of the subjects. It is interesting to note that of the 28 subjects who did not know about their facility's disposal policies, only 13.3% of them stated that this interview question made them want to know more about the policies.

3. *What do you think happens to the electronics that are not recycled here?* A big majority (76.7%) stated that they do not really know what happens to the electronics that are not recycled at the facilities. Of these people, 46.7% guessed that it would end up in the trash and become disposed somehow, but none of these people knew how or where, as they did not know what even happens to the regular trash that we throw away. Among these people was a common

theory that even though the electronics are thrown in the trash, they must somehow be recycled or disposed separately within the trash system, as one subject said, "I mean, they won't just blindly lump everything together just because it was thrown in the dumpster, would they?" The other 23.3% seemed to know that electronics not recycled properly would end up in landfills as e-waste. However, as reiterated from the answers from the last interview question, only 6.7% of subjects knew that electronics not recycled in facilities could be shipped overseas for disposal.

4. *What would you think if the e-waste you leave today is "recycled" in a poor developing country?* With the exception of the two subjects who knew about this exact issue, 83.3% stated that it was the first time they have heard of such an issue whereas 10% stated that they have heard of the issue before but never knew the implications. Those who were unaware said they had no idea how different countries could be involved with a domestic e-waste recycling issue. The interview question gave a brief description of the details of the issue (Appendix C). When they were all informed, 86.7% stated that they were deeply concerned that such facilities could even exist, and expressed much more anxiety than before. These subjects said they would try to be more mindful in the future of the effects of recycling and how it impacts the environment. One subject looked visibly disturbed as she said, "Are you serious? God, it didn't even enter my mind that something like that could be happening? Thank you for letting me know because I'm going straight back in there and asking for myself," and she hurried back into the facility. The other 13.3% stated that this would not affect their daily lifestyle choices with regards to recycling.

Discussion

The study validated the first hypothesis by demonstrating positive, albeit weak, relationship between educational levels and knowledge of environmental impacts. However, the second hypothesis proved untrue as the overall trend noticed among subjects during the interview showed general care when it comes to the actual processes of an e-waste recycling facility.

As the results indicate, those with higher educational levels tend to realize more about how their recycling affects the environment. It is suspected that with higher education comes with more awareness to see the environmental impacts when recycling is not done. The interview also tended to show that those with longer educational backgrounds were more knowledgeable about

e-waste issues and the necessity of recycling. Even with a small sample size of 30 subjects, it was still possible to see this trend.

These results are in support with the previous study that concluded that those who were more educated in concepts such as recycling and sustainability as they have grown up were more likely to understand their impacts on the environment (Pike *et al.* 2003). It may be that those who are educated are more informed about recycling, and these realizations about their recycling on environmental impacts are solidified especially as they experience higher education in college and beyond. Science education in higher educational establishments such as college has shown to greatly increase sustainability awareness among students (Pike *et al.* 2003). When exposed to such information in college or greater, these people are more likely to feel the need to recycle. Thus, social influences such as educational level are shown to be one of many motivations in determining conservation and sustainability behavior (Granzin & Olsen 1991). However, another previous study suggests that only age and gender can be used as factors in the socio-demographic characterization of environmentally concerned consumers, where one of the many ways the study defines environmentally concerned consumers is the socially conscious recycler (Ebreo *et al.* 1999). The study does not explain why they do not consider educational level as a variable in their experiments, but the scale of this study is much larger than my research in terms of sample size and time, and they were able to see much stronger correlation from those two variables than with any other variables such as sex or income. This is interesting because a similar study done by Ebreo just nine years before that concluded that the effect that demographic characteristics have on shaping the role of a recycler changes over time due to the changing society and current value systems. This seems to indicate that as time passes, different socio-demographic variables have had more of an influence than others in defining the motivation behind people who recycle voluntarily (Vining & Ebreo 1990), which had led me to suspect education in the first place. This is promising because we can see that 10 years later after Ebreo's last research, other variables such as education are playing a bigger role in shaping the identity of a recycler, and as the education system improves with time, it is plausible to see it encourage people to recycle more.

The findings on the general consumer care for the processes of e-waste recycling facility's disposal policies was surprising especially because an overwhelming majority were unaware of them initially. It was only when the subjects were informed about issues about overseas e-waste dumping and shown the pictures of the harsh working conditions in these settings did they seem

to realize the gravity of the issue. Many showed deep concern and a couple subjects went back into the facility to put to test their new knowledge. It is suspected that when these subjects realized that they themselves could be affected by this issue and was unaware the entire time, they were suddenly more concerned about the impact of their own actions. This can be largely attributed to the risk perception associated with becoming more knowledgeable about environmental issues that directly involves them (O'Connor *et al.* 1999).

Waste accumulation is a serious issue today with millions of tons attributed to just e-waste. Research done in the field of recycling and sustainability has seldom made the connection between societal influences and recycling, and only recently has there been efforts to do such. We need to be able to study the motivations behind recycling so that we can stop the problem from its source. This study attempts to assess the relationship between a person's educational level and their knowledge of environmental impacts. This will help people to understand the value of higher education so that students can be better equipped to address the importance of taking care of our environment.

In the attempts to perform this study successfully, there have been many shortcomings. Due to a brief data collection period of only three weekends, I had to work with a small sample size to perform my analysis. A bigger sample size could have been more representative of the recycling population. The majority of my subjects had Bachelor's Degree or higher with none below a high school degree, and this may be that the weekends attract a different group of people than what is representative of the recycling population. Also, my research only considered recyclers and not non-recyclers, which would be great to consider in future research since it would be interesting to observe why people choose not to recycle. A comparison between the two can reveal a more comprehensive report on how educational levels affect recycling. Due to time constraints, I was also unable to compare and contrast the other demographic variables in the study with regards to recycling. This would have been interesting to see how trends among the variables characterize a recycler and whether certain variables factor greater than others. A future research topic could also delve into the relationship between the knowledge of environmental impacts and its direct influence on people's tendency to recycle. For my research, it was assumed that someone who knew how their recycling could impact the environment would regularly recycle. Also, a big part of my research was concerning the legitimacy of e-waste recycling facilities, and with my lack of resources, I was unable to verify whether these facilities actually executed honest business

practices. If a future study was able to perform the investigative work of 60 Minutes, consumers could actually be told the truth about these businesses rather than raising hypothetical situations. It was clear that some of the subjects were unable to see the importance of the issue, as I was unable to prove that it was actually affecting them without knowing if these companies practiced proper disposal. It would be difficult to gauge honest responses if a situation was not really affecting subjects and rather having them use their imaginations instead.

In conclusion, it is important to consider the role of the educational system when determining the motives behind recycling. It is shown through this study that one's educational background has some influence on whether or not they will recycle in the future. To address the issue of growing e-waste, it is important to diagnose from its source. If we are to control the production of e-waste through recycling, it is necessary to control the motivation behind whether people have the tendency to recycle, and it is through this study that has determined the importance of higher levels of education which can lead to increased knowledge of environmental impacts. Also, those who recycle their electronics at e-waste recycling facilities should better monitor how their local facilities operate and be more proactive in the issues concerning e-waste dumping overseas. This is essential as consumer's actions can keep e-waste recycling facilities accountable for their actions and play a huge role in disclosing those who are engaged in illegal dumping.

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Appendix A: Informed Consent

Screening

Hi, have you recycled something at this e-waste recycling facility today?

Introduction

My name is Han Lee. I am an undergraduate at the University of California, Berkeley working with my faculty advisor, Professor Steve Welter in the Department of Environmental Sciences, Policy, and Management. I am planning to conduct a research study, which I invite you to take part in.

You are being invited to participate in this study because you have been selected one out every three people who have exited this e-waste recycling facility to avoid selection bias.

Purpose

The purpose of this study is to gather the general public's perceptions on electronic waste (e-waste) recycling in the Bay Area, and their knowledge and awareness of e-waste facility policies.

Procedures

If you agree to be in this study, you will be asked to do the following:

- I will hand you a questionnaire for you to fill out about your demographic information.
- After you fill out the questionnaire, I will ask you a four interview questions based on your opinions about e-waste recycling and your experience here at the facility today.
- The interview process will be audio recorded.

This entire process should take approximately 10 minutes.

Benefits

There is no direct benefit to you anticipated from participating in this study. However, it is hoped that the information gained from the study will help researchers and experts figure out ways to remedy issues related to e-waste recycling.

Risks/Discomforts

There should not be any risks for you to consider, but should you happen to feel uncomfortable in any way during the questionnaire or the interview, you may leave the research at any time.

Confidentiality

I will not attempt to know your name at all. I will refer to you only by a subject number. The audio recordings of the interviews will be stored in my home in a safe place away from other

people. Upon finishing the research paper, I will destroy these recordings by deleting them so that they are never to be accessed by anyone again.

Compensation

You will not be paid for taking part in this brief study.

Rights

Participation in research is completely voluntary. You have the right to decline to participate or to withdraw at any point in this study without penalty or loss of benefits to which you are otherwise entitled.

Questions

If you have any questions or concerns about this study, you may contact me, Han Lee, at (408)207-8439 or stevenhglee@gmail.com.

If you have any questions or concerns about your rights and treatment as a research subject, you may contact the office of UC Berkeley's Committee for the Protection of Human Subjects, at 510-642-7461 or subjects@berkeley.edu.

Appendix B: Questionnaire

1. What is your sex? (Male or Female)
   - ☐ Male
   - ☐ Female

2. What is your ethnicity?
   - ☐ White
   - ☐ Asian or Pacific Islander
   - ☐ Hispanic/Latin American
   - ☐ Black/African American
   - ☐ Other _____
   - ☐ Decline to state

3. What is your age?
   - ☐ 18-24 years
   - ☐ 25-30 years
   - ☐ 31-40 years
   - ☐ 41-50 years
   - ☐ 51-60 years
   - ☐ Over 60 years

4. What is the highest level of education you have completed?
   - ☐ Less than 9^{th} grade
   - ☐ High School
   - ☐ Some College, no degree
   - ☐ Technical or Associate Degree
   - ☐ Bachelor's Degree or higher

5. What is your personal total annual income?
   - ☐ Under $20,000
   - ☐ 20,000-$39,999
   - ☐ 40,000-$59,999
   - ☐ 60,000-$79,999
   - ☐ 80,000-$99,999
   - ☐ Over $100,000

6. What type of electronic good(s) did you recycle today?
   - ☐ Computer and/or accessories
   - ☐ Cellular phone and/or accessories
   - ☐ Other electronics

7. On a scale of 1 to 10, where 1 = no knowledge at all and 10 = very knowledgeable, how knowledgeable are you about environmental impacts?

   Answer:

Appendix C: Interview questions

1. Why did you decide to recycle today?

2. What do you think happens to the electronics that are recycled here?

3. What do you think happens to the electronics that are not recycled here?

4. (Provide brief background on the current issues about shipment of e-waste to foreign countries: Approximately 50-80% of the e-waste produced in the U.S. that do not enter landfills or incinerators are exported overseas to developing countries where loose regulations permit these shipments and allow dumping into particularly poor rural communities. In particular, a 60 Minute segment on November 9th, 2008, portrayed a seemingly well-to-do Colorado-based recycling company that allegedly engaged in illegal dumping of e-waste in poor communities of Hong Kong. Also show pictures from the harsh working conditions in these communities) What would you think if the e-waste you leave here today is shipped and dumped overseas to poor third world countries to exploit their cheap labor?